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HARVESTING WHEAT WITH A COMBINED HARVESTER-THRESHER IN THE GREAT PLAINS REGION, 1926

By R. S. KIFER, *Division of Farm Management and Costs;* W. R. HUMPHRIES, *Division of Agricultural Engineering;* J. H. MARTIN, *Office of Cereal Crops and Diseases*

The use of the combined harvester-thresher in the Great Plains region has been rapidly increasing. Until the past few years practically all of the grain in this region was harvested with a binder or a header. At the present time the combine is used extensively in some sections although much of the grain is still harvested with other machines.

Combines have been used for many years in certain districts on the Pacific coast, but the type of machine formerly used was not considered practicable by farmers of the Great Plains. Most of the older combines were large machines, cutting a swath of 20 or 24 feet, and drawn by large tractors or by teams of 20 to 36 horses. Power to operate the thresher unit was taken from the ground drive of the machine and the threshed grain was sacked and dropped in the field. Such a machine required a crew of five men and the harvesting-threshing season extended over a long period. In certain sections the machines were equipped with hillside or leveling devices.

The development of the small prairie type of harvester-thresher gave the farmer a machine which is becoming generally used in the Great Plains region. Although capable of handling the acreage usually found on farms in this region the machine has a narrower cut, is operated by a comparatively small crew, and usually is drawn by a light tractor. The power for the thresher is either derived from an independent power unit mounted on the combine or taken directly from the tractor which pulls the machine.

A few combines were used in the Great Plains in 1918. These combines usually had a 9-foot or 12-foot cut, were equipped with auxiliary motors, and were pulled either by horses or tractors. Most of the combines used in 1926 had a 15-foot or 16-foot cut. These machines increased in popularity and in many sections of the Great Plains practically all of the 1926 wheat crop was harvested with combines.

New model combines with a width of cut of 8 or 10 feet, drawn by a tractor, and with a direct power drive from the tractor itself, were being introduced in 1926. Such a machine has particular advantages in being operated by a smaller crew, and in requiring

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a smaller investment than arlge do the machines with auxiliary motors. These power-driven machines were used on farms with comparatively small acreages of wheat.

STUDY OF COMBINE OPERATION

To determine the practicability and efficiency of the harvester-thresher in the Great Plains, a study was made of combine operation in selected districts in Texas, Oklahoma, Kansas, Nebraska, and Montana, and records were obtained from farmers who operated these machines during the harvest season of 1926.

In all of the districts where records were obtained the farmers who were using combines were unanimous in stating that the combine is a practical and efficient harvesting machine. With a very few exceptions the farmers considered the machine to be a profitable investment. The experience of nearly all of these farmers is that the combine has reduced the cost of harvesting and threshing. The labor required for harvest is reduced, and as a larger proportion of the labor is performed by the operator or members of the family, the expense for hired labor is decreased. The cost of twine for binding and the cost of threshing is eliminated. Advantages given less frequently by the combine operators are that the season of harvest and threshing is shortened and the fields are cleared so that the work of preparation for the following crop can be done in better season. Some farmers considered that the combine wastes less grain than other methods of harvesting, others stated that their labor difficulties of obtaining and retaining a harvest crew are decreased. Many farmers considered the reduction in cost of boarding hired help and the lessened work for the women in the house very important considerations.

WHAT CAN BE ACCOMPLISHED WITH A COMBINE

Many of the farmers purchased their present machines when they had had no previous experience in the use of a combine to guide them in choosing a machine fitted to their purpose. As a result some farmers found their machine too small to handle their acreage of grain, with subsequent losses from long-standing grain or from the expense of hiring some grain harvested. Others found their machines too large for economical use on their own farms. In all sections at present, however, custom work with the combine can be done at a profit and in some instances the operators purchased machines larger than were needed for their own crop in order to take advantage of the profit in custom cutting.

The machines commonly used in the Great Plains have a 12-foot, 15-foot, or 16-foot cut and are equipped with an auxiliary motor, or are 8 or 10 foot machines with direct power drive from the tractor. The few ground-drive machines found are not included in the tabulations. All of the power-drive machines and all except a very few of the combines with auxiliary engines were drawn by tractors. A few machines in each locality were pulled with horses but because the number was small the records of the horse-drawn combines are omitted from most of the tabulations. The number of combines included in the tables which follow depend upon the data to be shown. Certain combines have been omitted from some of the tables because of

incomplete data or other irregularities which render them incomparable with the combines included in the study.

The average acreage cut annually by combines of all types and sizes was 553 acres per machine. Of this acreage, 365 acres were cut on the operator's own farm and 188 acres were cut for others. Very little grain other than wheat was cut although some farmers used their combines, to harvest small acreages of oats, barley, and rye.

The harvesting season for all crops came at practically the same time of the year, and the acreage of other crops was so small that the harvesting season was not generally prolonged by crops which ripen at different times during the season. In the Judith Basin of Montana both spring and winter wheat are grown and as there is a difference of one or two weeks in the time of ripening of the two classes of wheat, the harvesting season is somewhat longer, consequently the acreage cut per machine was somewhat greater there than in the other districts. Table 1 shows the acres cut annually by combines of different types and sizes. The averages represent acres cut per machine in all districts regardless of kind of grain harvested. The table indicates the acreage which a machine of a given size may be expected to cut in this region.

Table 1.—*Acres cut annually with combines of different types and sizes*

Type of combine	Combines	Width of cut	Acreage cut per machine[1]		
			Own grain	Custom cutting	Total
	Number	*Feet*	*Acres*	*Acres*	*Acres*
Tractor drawn with power take-off	25	8	215	60	275
	10	10	292	165	457
Tractor drawn with auxiliary engines	56	12	301	107	408
	51	15	378	196	574
	104	16	428	254	682
	3	20	700	377	1,077
All tractor drawn	249		365	188	553

[1]Acreage cut per year for the time the machine has been in use.

For machines with a direct power drive, the 8-foot machines averaged 275 acres per combine and the 10-foot machines averaged 457 acres. The proportionally higher acreage cut by the 10-foot machines may be due in part to the regional difference in the Great Plains. A large proportion of the 10-foot machines were reported in the Judith Basin of Montana where both winter and spring wheat are grown, and where the acreage per farm is larger than in other areas of the Great Plains where studies were made.

Of the machines equipped with auxiliary engines the average cut with a 12-foot machine was 408 acres; with a 15-foot machine, 574 acres; and with a 16-foot machine, 682 acres. Not all of the difference in acres cut annually can be explained by differences in size of the machine. The 12-foot machines were generally older and were not used for custom cutting to the same extent as were the larger combines. Here again, the regional location of the combine, the extent of the wheat acreage in the particular locality, and the length of

harvesting season also affected the extent to which the combine was used.

Some custom cutting was done with machines of all sizes, but the larger machines usually did a larger proportion of outside work than the small machines. Some operators purchased machines larger than necessary to handle their own crop with the express purpose of cutting for others. The size of machine owned has only a general relation to the acreage of the operator's own grain. On some farms the machine was too small to care for the owned crop, whereas on other farms the capacity of the machine was not fully utilized.

The annual capacity of the combine is determined jointly by the length of the harvesting season and the daily capacity of the machine. In some sections, where the weather conditions are such that the grain may be allowed to stand for a considerable period without great danger of loss from shattering or damage from weather, the long harvesting season may enable an operator to cut his crop with a small machine. On the other hand, under conditions of heavier rainfall or greater risk from weather, a larger machine would be required to harvest the same acreage. The size of machine needed to cut a given acreage should be estimated from the daily capacity of the combine and the number of days which the machine probably will be used.

The rate of cutting per hour of a machine should be determined by the length of the cutter bar and the rate of travel. Some time is lost in the field in turning, oiling, making minor adjustments, and in removing the grain from the combine. Because of the variation in the time lost on different machines, the rate of travel and the hours worked per day do not accurately indicate the distance covered. The usual rate of travel is from 2.5 to 3 miles per hour and is apparently not related to the size of machine. Such differences as are shown in Table 2 indicate a higher rate of travel for machines equipped with auxiliary engines. Unless the advantage of a higher rate of speed is offset by greater loss of time in the field the rate of cutting should be increased in proportion to the increase in rate of travel. Where the crop is heavy the rate of travel may be limited by the capacity of the separator to handle the grain.

TABLE 2.—*Acres cut per hour and per foot of cut by combines of different types and sizes*

Type of combine	Combines	Width of cut	Yield per acre	Rate of travel	Length of day	Cut per day	Cut per hour	Cut per hour per foot of width
	Number	*Feet*	*Bushels*	*Miles per hour*	*Hours*	*Acres*	*Acres*	*Acres*
Tractor drawn with power take-off	25	8	17	2.4	10.3	16	1.6	0.19
	10	10	24	2.7	9.8	26	2.6	.26
Tractor drawn with auxiliary engines	56	12	17	2.8	10.2	27	2.6	.22
	51	15	18	2.8	10.3	35	3.4	.23
	104	16	21	2.8	10.7	40	3.8	.24
	3	20	25	2.4	10.7	48	4.5	.22
All tractor drawn	249	--------	19	2.8	10.4	33	3.2	--------

At times the amount of work done in a day is restricted by the hours which the combine can be used. The average length of day for all operators, as given in Table 2, was 10.4 hours. In a few instances the combines were operated the full 24 hours of the day and not uncommonly the machines were used for 15 or 16 hours. In more instances, however, under conditions of high humidity some time was allowed for the grain to dry, and the working day was thus shortened.

The larger machines of course cut a greater acreage in a given length of time than does a smaller machine. The acres cut per hour by the power-drive machines showed an average of 1.6 for the 8-foot machines and 2.6 for the 10-foot machines. The difference in rate of cutting was greater than can be accounted for by the difference in size of the machine. Machines with auxiliary engines having a 12-foot width of cut averaged 2.6 acres per hour, those with a 15-foot cut averaged 3.4, and those with a 16-foot cut averaged 3.8 acres. The difference in rate of cutting for these machines was approximately proportional to the difference in size, and the greater acreage cut by the wider machines was presumably due to the advantage of size.

The rate of cutting per hour for each foot of cut should, with due allowance made for time lost in the field, depend entirely on the rate of travel. As there was no apparent relation between the size of the machine and the rate of travel per hour, little difference was shown in the rate of cutting per foot of width for machines of different sizes. The high rate of cutting per hour and per foot of width for the 10-foot machines probably was due to fewer stops and less time wasted in the field.

INFLUENCE OF SEPARATE FACTORS ON RATE OF CUTTING

The size of the machine is the most important single factor directly affecting the rate of cutting. With two other factors, rate of travel and yield of grain remaining constant, the rate of cutting per hour, as derived from 211 reports of combines equipped with auxiliary engines, would be increased 0.27 acres by the addition of each foot to the length of the cutter bar.[1]

On this basis a 10-foot machine in 20-bushel wheat and traveling at 2.5 miles per hour, should cut 20.5 acres in a 10-hour working day. A 12-foot machine should cut 25.9 acres, a 15-foot machine 34 acres, a 16-foot machine 36.7 acres, and a 20-foot machine 47.5 acres. These estimates of operation check fairly closely with the averages given in Table 2.

The estimated rate of travel reported does not accurately represent the ground covered by the machine in a given time. The reported figure makes no allowance for lost time and does not give a true average rate of travel. An increase in acres cut proportionally less than the increase in rate of travel is indicated by the average relation existing between acres cut per hour and the reported rate of travel.

Yields ordinarily reported in the Great Plains have little effect on the rate of cutting per hour. Except in cases of heavy yields, the machine can handle the cut grain without difficulty. Where yields

[1] This increase is an average relationship shown by a linear multiple correlation analysis giving a coefficient of correlation of 0.81. The regression equation on which it is based is: $D=0.27A-0.004B+0.225C-1.21$; where A is the length of the cutter bar in feet, B is the acre yield in bushels, C is miles traveled per hour, and D is the number of acres cut per hour. This means that, with other factors remaining the same, an increase of 1 foot to the width of machine would be expected to increase the rate of cutting 0.27 acres per hour. For each additional bushel of yield with no change in other factors the rate of cutting would be expected to decrease by 0.004 acres per hour. Each increase of 1 mile per hour in rate of travel was associated with an increase of 0.255 acres cut per hour.

of wheat exceed 30 bushels per acre it may be necessary to reduce the rate of travel in order that the combine may handle the grain without undue loss. In lodged grain where a great deal of straw is handled the rate of travel may also be reduced.

ELEMENTS OF COST IN HARVESTING WITH A COMBINE

Operating expenses for harvesting with a combine consist of cost of fuel and lubricants, use of tractor, labor, and repairs on the combine. Fixed charges to be made against the combine are charges for depreciation and interest on the investment.

POWER, FUEL, AND LUBRICANTS

The charge to be made for the use of the tractor in combining would probably vary somewhat with size of tractor, and in actual accounting it would be affected largely by the amount of other work for which the tractor was used. Except for a few instances in which a tractor was hired, the tractor was used for other farm work. A few tractors were hired for 50 or 60 cents per acre where driver and fuel were furnished by the combine operator. The rate may be applied regardless of size of the tractor for, although a larger tractor would be used on large combines, the acreage covered would be proportional to the combine and the total returns commensurate with the size of tractor.

There is also some variation in size of tractors used on machines of the same size. In many cases the tractor was purchased primarily for other farm work, and as a result the tractor may be larger or smaller than the size best suited to the combine. Where the tractor is already available or is to be used for other work it may be good practice to use the power available rather than to purchase a tractor which is fitted to the size of the combine. Other differences in horsepower of tractors used may arise from differences in soil types or in topography. On farms with a rolling topography or light soil a larger tractor may be required than on farms with level surface and firm soil. The motive power must be sufficient to provide a steady rate of travel under all conditions. A few operators used two tractors and others supplemented the tractor power with horses where the surface was rolling or the ground soft.

The size of tractor used on combines of different width of cut is shown in Table 3. Of the combines equipped with auxiliary engines and cutting 12 feet, 34 per cent were pulled by tractors of 12 drawbar horsepower or less, 55 per cent were pulled by 15 or 16 horsepower tractors, and 16 per cent were pulled by tractors of larger size than 16 horsepower. Larger tractors were generally used on the 15 and 16 foot machines. Only 14 per cent of the 51 machines with a 15-foot cut used tractors rated at 12 horsepower or less, 61 per cent used tractors of 15 or 16 horsepower, and 25 per cent used larger tractors. There is very little difference in size of tractors used on 15 and 16 foot combines. Of the 104 machines with a 16-foot width of cut, only 16 per cent used tractors of less than 15 horsepower, 43 per cent used 15 or 16 horsepower tractors, and 40 per cent used tractors larger than 16 horsepower. The 15-horsepower tractor was most generally used on all sizes of machines with auxiliary engines.

TABLE 3.—*Power used on combines of different types and sizes*

Type of combine	Combines		Size of tractor used[1]					Horses used		
	Width of cut	Farms	12 horsepower or smaller	15 to 16 horsepower	17 to 18 horsepower	20 to 30 horsepower	31 to 45 horsepower	6	8	10
	Feet	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Tractor drawn with auxiliary engines	12	56	19	31	3	3	----	----	----	----
	15	51	7	31	9	3	1	----	----	----
	16	104	18	45	29	12	----	----	----	----
	20	3	----	1	----	2	----	----	----	----
Tractor drawn with power take-off	8	25	25	----	----	----	----	----	----	----
	10	10	----	10	----	----	----	----	----	----
Horse drawn	12	3	----	----	----	----	----	1	2	----
	15	3	----	----	----	----	----	----	2	1
	16	2	----	----	----	----	----	----	2	----

[1] Draw-bar horsepower.

All of the 8-foot power-drive combines were operated by small tractors, and all of the 10-foot power-drive machines were operated by 15 horsepower tractors.

The fuel used in the tractor varies for the different sizes and for individual tractors of the same size. Since the large combines usually are pulled by large tractors, the fuel consumption per tractor is larger for the 15-foot and 16-foot than for the 12-foot machines. A larger acreage is cut by the wider machines, however and, as shown in Table 4, the fuel used in the tractor is less per acre for the large machines. The average for all combines equipped with auxiliary engines is 0.80 gallons of fuel per acre. The average tractor fuel consumption is 0.94 gallons for the 12-foot machines, 0.84 gallons for the 15-foot machines, and 0.75 gallons per acre for 16-foot machines.

TABLE 4.—*Fuel and lubricants used in tractors*

Type of combine	Combines		Acres cut	Grain threshed
	Width of cut	Number		
	Feet			*Bushels*
Tractor drawn with power take-off	8	25	213	3, 647
	10	10	292	7, 108
Tractor drawn with auxiliary engines	12	54	287	4, 876
	15	50	357	6, 385
	16	103	423	8, 669
	20	3	637	15, 918
All tractor drawn with auxiliary engine	----	210	375	7, 166

Type of combine	Fuel used per farm						Oil used		
	Gasoline	Kerosene	Distillate	Total	Per acre	Per bushel	Per farm	Per acre	Per bushel
	Gallons	*Gallons*	*Gallons*	*Gallons*	*Gallons*	*Gallon*	*Gallons*	*Gallon*	*Gallon*
Tractor drawn with power take-off	114	127	21	262	1. 23	0. 072	12	0. 05	0. 003
	200	139	42	381	1. 30	. 054	12	. 03	. 002
Tractor drawn with auxiliary engines	153	100	16	269	. 94	. 055	13	. 04	. 003
	148	124	27	299	. 84	. 047	12	. 03	. 002
	201	97	18	316	. 75	. 036	15	. 03	. 002
	292	----	133	425	. 67	. 027	13	. 02	. 001
All tractor drawn with auxiliary engine	178	103	21	302	. 80	. 042	13	. 04	. 002

The combines with direct power drive from the tractor used more fuel per acre in the tractor than did those equipped with auxiliary engines. The fuel used in these machines should be compared to the total fuel used in machines having two power units.

Gasoline or kerosene is commonly used for tractor fuel, although a few of the operators used distillate. The quantity of fuel used per day by a given machine is approximately the same regardless of the kind of fuel.

The amount of fuel and lubricants used by combines with auxiliary engines was reported separately for the tractor and the auxiliary engine. Table 5 shows the quantity of fuel and oil used in the auxiliary engine. With one or two exceptions, the farmers used gasoline as the motor fuel in the combine engine. The amount of fuel and oil used during the season depended directly on the acreage cut. Fuel consumption per acre showed the larger machines to be slightly more economical than small machines. Machines with a 12-foot cut used 0.61 gallons per acre, those with a 15-foot or 16-foot cut used 0.59 gallons per acre. The difference in average fuel consumption between the groups was less than the variation shown between combines o the same size. Differences in condition of the engine, rate of travel and yield of wheat, as well as size of machine, affect fuel consumption

TABLE 5.—*Fuel and lubricants used in the auxiliary engine*

Type of combine	Combines		Acres cut	Grain threshed	Gasoline used			Oil used		
	Width of cut	Number			Total	Per acre	Per bushel	Total	Per acre	Per bushel
	Feet			*Bushels*	*Gallons*	*Gallons*	*Gallons*	*Gallons*	*Gallons*	*Gallons*
Tractor drawn with auxiliary engines..	12	54	287	4,876	176	0.61	0.036	7	0.02	0.001
	15	50	357	6,385	211	.59	.033	8	.02	.001
	16	103	423	8,669	249	.59	.029	11	.03	.001
	20	3	637	15,918	250	.39	.016	12	.02	.001
All tractor drawn with auxiliary engine		210	375	7,166	221	.59	.031	9	.02	.001

The average relation between size of machine and fuel consumption per acre showed the machines with longer cutter bar to be more economical than those with shorter ones. This economy may be due in part to the use of extension cut on a number of machines. The separator on some of the 15 or 16 foot machines was the same size as on the 12-foot and consequently required less fuel per acre cut. The difference between the amounts estimated for a 10-foot machine and for a 20-foot machine is only 0.13 gallons per acre.[2]

Rate of travel per hour has a more significant effect on the consumption of fuel. Presumably the amount of fuel used in the engine in a given period of time differs very little regardless of whether th e

[2] This estimate is based on a multiple linear correlation analysis of fuel used per acre as affected by size of machine, yield of grain, and rate of travel per hour. The coefficient of correlation is +0.92. The effect of each factor on fuel used is estimated from the regression equation, $E = 2.127 - 0.013A + 0.0084B - 0.536C$ when E is the fuel used per acre, A is lenth of the cutter bar in feet, B is yield of grain in bushels, and C is miles traveled per hour. The average relationship expressed is that, with no change in the other factors, an increase of one foot in width of cut would be associated with a decrease of 0.013 gallons of fuel for each acre cut. An increase of 1 bushel per acre in yield would be associated with an increase of 0.0084 gallons of fuel used per acre and an increase of 1 mile per hour in rate of travel would reduce the fuel consumed by 0.536 gallons per acre. In making these estimates care must be taken to keep the measure of the casual factors within the limits of the data on which the correlation is based.

machine travels at 2 or 3 miles per hour. Consequently a 15-foot machine cutting grain yielding 20 bushels per acre would burn approximately 1 gallon of fuel per acre traveling at 2 miles per hour, but would use proportionally less when traveling at 3 miles per hour. For economical use of gas in the auxiliary engine it would be advisable to pull the machine at as high a rate of speed as is consistent with efficient harvesting.

In heavy wheat it may be necessary to reduce the rate of travel in order that the combine may efficiently separate the grain. This effect of yield on fuel consumption per acre is reflected in the relation between the rate of travel and fuel consumption per acre.

With a constant rate of travel the yield of grain per acre has some separate effect on fuel used. The estimated fuel used by a 15-foot machine traveling at 2.75 miles per hour in grain yielding 10 bushels per acre is 0.54 gallons per acre; for a 20-bushel yield, under the same conditions, the estimated fuel consumption is 0.62 gallons; and for a 30-bushel yield the fuel consumption is 0.71 gallons per acre.

Since the amount of fuel per acre used in threshing grain with a high yield is not much greater than that used for threshing a low yield, the amount of fuel per bushel is affected largely by the yield of grain. For high yields, the fuel used per bushel is small compared with that for low yields. The lubricants used for the auxiliary engine make up a small item of expense and the amount is roughly proportional to the fuel used.

Fuel consumption per bushel of grain is largely dependent on the yield per acre, but in general the amount of fuel required per bushel is less for the large than for the small machines.

The total quantity of fuel and oil used for harvesting with a combine is shown for each type of machine in Table 6. The average fuel used per acre in units with auxiliary engines is 1.39 gallons. For combines with the power drive from the tractor the fuel per acre is slightly less. For the combines with auxiliary engines the amount of fuel per acre is generally less for large than for small machines. The 8-foot power-drive machines show a smaller fuel consumption per acre than the 10-foot power-drive machines; but the yield of grain was consistently higher where most of the 10-foot machines were used, and the higher fuel consumption is due in part at least to the heavier grain. The fuel consumption per bushel is less for the 10-foot than for the 8-foot combines.

TABLE 6.—*Fuel and lubricants used for combining* (*tractor and auxiliary engine*)

Type of combine	Combines		Fuel used			Oil used			Grease used		
	Width of cut	Number	Total	Per acre	Per bushel	Total	Per acre	Per bushel	Total	Per acre	Per bushel
	Feet		*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Galls.*	*Lbs.*	*Lbs.*	*Lbs.*
Tractor drawn with power take-off	8	25	262	1.23	0.072	12	0.05	0.003	13	0.06	0.004
	10	10	381	1.30	.054	12	.04	.002	18	.06	.002
Tractor drawn with auxiliary engine	12	54	445	1.55	.091	20	.06	.004	18	.06	.004
	15	50	510	1.43	.080	19	.05	003	18	.05	.003
	16	103	565	1.34	.065	26	.06	.003	17	.04	.002
	20	3	675	1.06	.043	25	.04	.002	38	.06	.002
All tractor drawn with auxiliary engines	--------	210	523	1.39	.073	22	.06	.003	18	.05	.002

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The quantity of oil has the same general relation to size of machine as has the fuel used. The grease used on the tractor and combine is a small item of cost and, as reported, the quantity used shows more variation between machines of the same size than in the case of either fuel or oil.

LABOR USED ON COMBINES

The size of crew used on the combine itself is fairly well standardized in the Great Plains. Machines with power drive from the tractor can be operated by one man and the machines with auxiliary engines are designed to use the labor of two men. Additional help is used on many machines either because the labor is available on the farm or through an effort to minimize the time necessarily lost in the field.

Table 7 shows the labor used on machines of different types and sizes. Of the 25 machines with an 8-foot cut, 23 were operated by 1 man. Of the 10-foot machines 3 were operated by 1 man, and 7 machines were operated by 2 men.

Table 7.—*Number of combines operated by crews of different sizes*

Type of combine	Width of cut	Number of combines	Size of crew [1]				
			1 man	2 men	3 men	4 men	5 men
	Feet						
Tractor drawn with power take-off	8	25	23	2			
	10	10	3	7			
Tractor drawn with auxiliary engine	12	56	1	51	4		
	15	51		42	9		
	16	104		79	22	2	1
	20	3			2	1	

[1] Includes combine operator, tractor driver, and helpers on the combine, but not grain haulers.

With a few exceptions, the combines with auxiliary engines were operated by at least one tractor driver and one man on the combine. This crew can handle the unit, but many farmers used extra men and a few used two complete crews. Of the 56 machines with a 12-foot cut, 1 was operated by 1 man, 51 used crews of 2 men, and 4 used crews of three men. Of the 51 machines with a 15-foot cut all used crews of 2 or more men, 1 used an extra tractor driver, and 8 used additional helpers. Of the 104 machines with a 16-foot cut, 2 used extra operators on the combine and 25 used additional helpers. The 20-foot machines all used crews of 3 men or more. More of the farmers with the large machines used extra men in order to reduce the time for oiling and making minor adjustments in the field.

The data available do not indicate that an increase in acres cut per day will result from the use of an extra man on the combine. Unless some greater efficiency in threshing is gained the extra help will not be justified by the extra work done. The extra man in a great many instances is used to relieve the regular workers or is carried as a sort of insurance against time lost through machine adjustments or through breakdowns that may be repaired in the field.

The reduction in amount of harvest labor hired for combine harvesting compared with that used with other methods is an important

consideration with many farmers. On the tractor-drawn combines from which records were obtained, 53 per cent of the labor was that of the operator or of unpaid labor on the farm. Some of the hired labor was regularly employed on the farm and a part represented labor exchanged with neighbors. The small amount of labor hired rendered the farmer comparatively independent of transient labor for his harvesting operations.

A higher grade of labor is usually hired for work on the combine than would be employed for harvesting with a binder or header, and wages are somewhat higher. Table 8 shows the number of paid and unpaid workers used in operating combines. Wages for the different operations differ somewhat in the different localities and show a still wider variation for different farms in the same locality. The most common rates paid for combine operators were $5 or $6 per day, and rates as low as $4 or as high as $8 were not uncommon. Customary rates for tractor drivers were $4, $5, or $6, and $4 was the usual wage for haulers. Helpers on the combine usually received wages similar to the haulers.

Table 8.—*Paid and unpaid labor on combines*

Type of combine	Width of cut (feet)	Number of combines	Number of operators		Number of helpers		Number of drivers	
			Paid	Unpaid	Paid	Unpaid	Paid	Unpaid
Tractor drawn with power take-off	8	25	20	8	--------	--------	--------	--------
	10	10	7	3	--------	1	2	5
Tractor drawn with auxiliary engine	12	56	22	34	4	3	29	26
	15	51	15	36	3	5	28	24
	16	104	30	76	14	11	62	42
	20	3	3	1	2	1	3	--------
Horse drawn	12	3	--------	3	--------	--------	2	1
	15	3	1	2	--------	--------	2	1
	16	2	1	1	--------	--------	1	1
Total	--------	257	99	164	23	21	129	100

The economy in the use of man labor is shown by a comparison of man-hours per acre used for different methods of harvesting. Where a binder is used, and the grain is cut, shocked, and threshed from the shock the labor per acre is about 3.6 man-hours. Where the wheat is harvested with a header the labor per acre is about 2.8 man-hours compared with about 0.75 man-hour for harvesting with a combine.[3]

The comparison given includes only the labor furnished by the farmer and does not include the labor furnished by the thresher. The cost of this threshing labor is included in the rate paid by the farmer for threshing. To obtain the saving in total labor made, approximately 1 hour per acre should be added to the figure given for harvesting with either a binder or header. A machine operated by a crew of 5 pitchers and 3 machine men, threshing 1,200 bushels in a

[3] Averages from 8 selected areas in Oklahoma, Kansas, and Nebraska for 1920. See U. S. Department of Agriculture Bulletin 1198.

10-hour day, would be equivalent to 1 man-hour of labor per acre in wheat yielding 15 bushels per acre.

The total labor for harvesting and threshing would be reduced from approximately 4.6 man-hours for cutting with a binder and threshing with a stationary thresher, or 3.8 man-hours for cutting with a header and threshing with a stationary thresher, to about 0.75 man-hour per acre where the work is done with a combine.

In each district, however, the labor of cutting, shocking, and hauling bundles to the thresher was furnished by the farmer and is included in the labor used for harvesting and threshing when grain is cut with a binder. The labor required where a header is used includes cutting and stacking but does not include pitching into the separator. The labor required for hauling grain is not included in either case.

The crew to operate a combine would be no larger than that to cut grain with a binder and shock. For a grain acreage so large that more than one binder would be needed a combine would reduce the size of the harvest crew. Compared with a header crew, the crew of a combine would be 2 or 3 rather than 6 men. The use of the combine also eliminates the crew necessary for stationary threshing.

REPAIRS ON COMBINES

The cost of repairs on 256 combines operated in 1926 as reported by the operators averaged $20 per machine for the season. In addition to this cash cost an average of 2 days of man labor was used in putting repairs on the combine and fitting the machine for the season's work. This average figure, shown in Table 9, does not represent the average repair cost for a machine for the entire length of its service. The average age of machines for which this figure is obtained is only 2.4 years, so that practically all machines were comparatively new and would be expected to show low costs for repairs. During the first year of operation practically all repairs are made as a service by the manufacturer and therefore are not reported by the farmer as costs. A group of older machines would show much higher charges for repairs. Average repairs shown were much higher on the 12-foot machines than on the others and it was this group that had been longest in service.

TABLE 9.—*Average costs of repairs on combines in 1926* [1]

Type of combine	Width of cut	Number of combines	Age	Repairs	Labor
	Feet		*Years*	*Dollars*	*Days*
Tractor drawn with power take-off	8	25	1.0	4	.6
	10	10	1.0	1	.3
Horse drawn	12	3	8.0	56	3.0
	15	3	1.3	5	----------
	16	2	1.5	24	2.0
Tractor drawn with auxiliary engine	12	56	4.9	40	3.4
	15	51	1.8	16	1.5
	16	103	1.7	18	1.9
	20	3	1.7	8	.2
Total	----------	256	2.4	20	2.0

[1] Average reported by operators for 1926.

TABLE 10.—*Repairs per acre on combines of different ages* [1]

Type of combine	Width of cut	Second year		Third year		Fourth year	
		Total	Per acre	Total	Per acre	Total	Per acre
	Feet	*Dollars*	*Cents*	*Dollars*	*Cents*	*Dollars*	*Cents*
Tractor drawn with auxiliary engine	12	30	7.5	33	8.7	34	9.9
	15	29	5.4	37	7.2	38	7.5
	16	29	4.4	45	6.3	----------	----------
All tractor drawn with auxiliary engine	----------	88	5.5	115	7.7	----------	----------

Type of combine	Fifth year		Sixth year		Seventh year		Eighth year	
	Total	Per acre	Total	Per acre	Total	Per acre	Total	Per acre
	Dollars	*Cents*	*Dollars*	*Cents*	*Dollars*	*Cents*	*Dollars*	*Cents*
Tractor drawn with auxiliary engine	35	10.3	41	12.5	42	11.3	70	17.4
	48	9.8	----------	----------	----------	----------	----------	----------
All tractor drawn with auxiliary engine	----------	----------	----------	----------	----------	----------	----------	----------

[1] Average per number of farms reporting.

Table 10 shows repair costs per acre of grain harvested for machines of all ages over 2 years. The repairs per acre on the 12-foot machines increased from 7.5 cents for the second season to 17.4 cents for the eighth season. The repairs on the 15-foot machines increased from 5.4 cents per acre for the second season to 9.8 during the fifth season. In general, repairs per acre are less for the large than for the smaller machines. Because of the inadequacy of repair data on older machines the average does not represent the allowance which should be made for cost of repairs.

The repair cost per acre is probably affected less by the acreage cut than is the depreciation charge per acre. Table 10 indicates that the machines which have been in use for about one-half of the expected life of the machine the cash cost of repairs would be approximately 10 cents per acre. In computing harvesting cost, an allowance of 10 cents per acre is made for purchase of repair parts on the combine.

DEPRECIATION AND INTEREST

The combine, with its economy in the use of labor and greater convenience in harvesting, has a disadvantage compared with other harvesting machines in requiring a large original investment, consequently having high depreciation and interest charges. The first cost of the machine varies with the size and type of machine purchased. Power-drive machines with an 8-foot or 10-foot cut may be priced as low as $1,000 and the larger machines equipped with auxiliary engines may cost $2,000 or $3,000, depending on the make and size of machine purchased. As so large an investment is required, many farmers with a small wheat acreage hesitate to purchase a combine.

Table 12 shows the average cost of machines of different types to farmers in the Great Plains region. This cost varies somewhat with the location, the terms of purchase, and the accessory equipment purchased with the machine.

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TABLE 11.—*First cost and expected life of combines*

Type of combine	Width of cut	Number of combines	Cost	Estimated years of life
	Feet		*Dollars*	*Number*
Tractor drawn with auxiliary engine	12	56	1,810	10.7
	15	51	2,084	7.0
	16	104	2,315	7.8
	20	3	3,315	11.7
Tractor drawn with power take-off	8	25	1,043	7.5
	10	10	1,260	8.5
Horse drawn	12	3	1,812	13.3
	15	3	1,903	7.0
	16	2	2,290	5.0
Total		257	1,995	8.3

For the most part the machines have been used for too short a time to determine the length of service to be expected under ordinary farm conditions. Moreover, the combine is in the process of development and a machine may decrease in value as much from becoming obsolete as from actual wear and tear. Estimates of the operators indicate that on the average the machines were expected to last about eight seasons. The expected length of life apparently has little relation to the acres cut annually and under conditions of actual operation is probably affected more by the mechanical ability of the operator and the care given the machine than by the amount of work done each season. For the 257 combines included in the study, depreciation as derived from first cost, estimated length of service, and acres harvested annually is 44 cents per acre. Annual depreciation is one of the most important costs to be considered in harvesting with a combine.

Assuming no relation between the acres cut annually and the life of the machine, the charge for depreciation would be a fixed cost and the charge per acre would depend largely on the acres cut each year. Utilizing a machine to its full capacity is a very important factor in reducing costs of harvesting with a combine.

An interest charge based on one-half the original investment at 6 per cent is taken to represent the average interest charge for the entire life of the machine. As a fixed cost this charge is decreased per acre as the number of acres cut is increased.

COMPARATIVE COSTS OF HARVESTING

Costs of harvesting grain differ in various sections of the country according to differences in the prices of the cost factors. There is some variation in prices of machines, wages of labor, and prices of fuel and lubricants in different parts of the Great Plains region. Some variation in costs per acre also occurs with differences in yields of grain, although this variation is less when costs are computed on an acre basis rather than on a bushel basis. A wide difference in acre costs occurs on different farms under similar conditions of weather, prices, and yields. Variations in such factors as length of life of the

machine, repairs, acres cut per day, and mechanical ability of the operator, cause variations in costs so that computations representing averages are not applicable to individual farms. In using the cost data shown in the tables and curves it is very important, therefore, that the individual farmer keep clearly in mind the fact that differences in costs do occur from farm to farm. Figure 1–A shows a

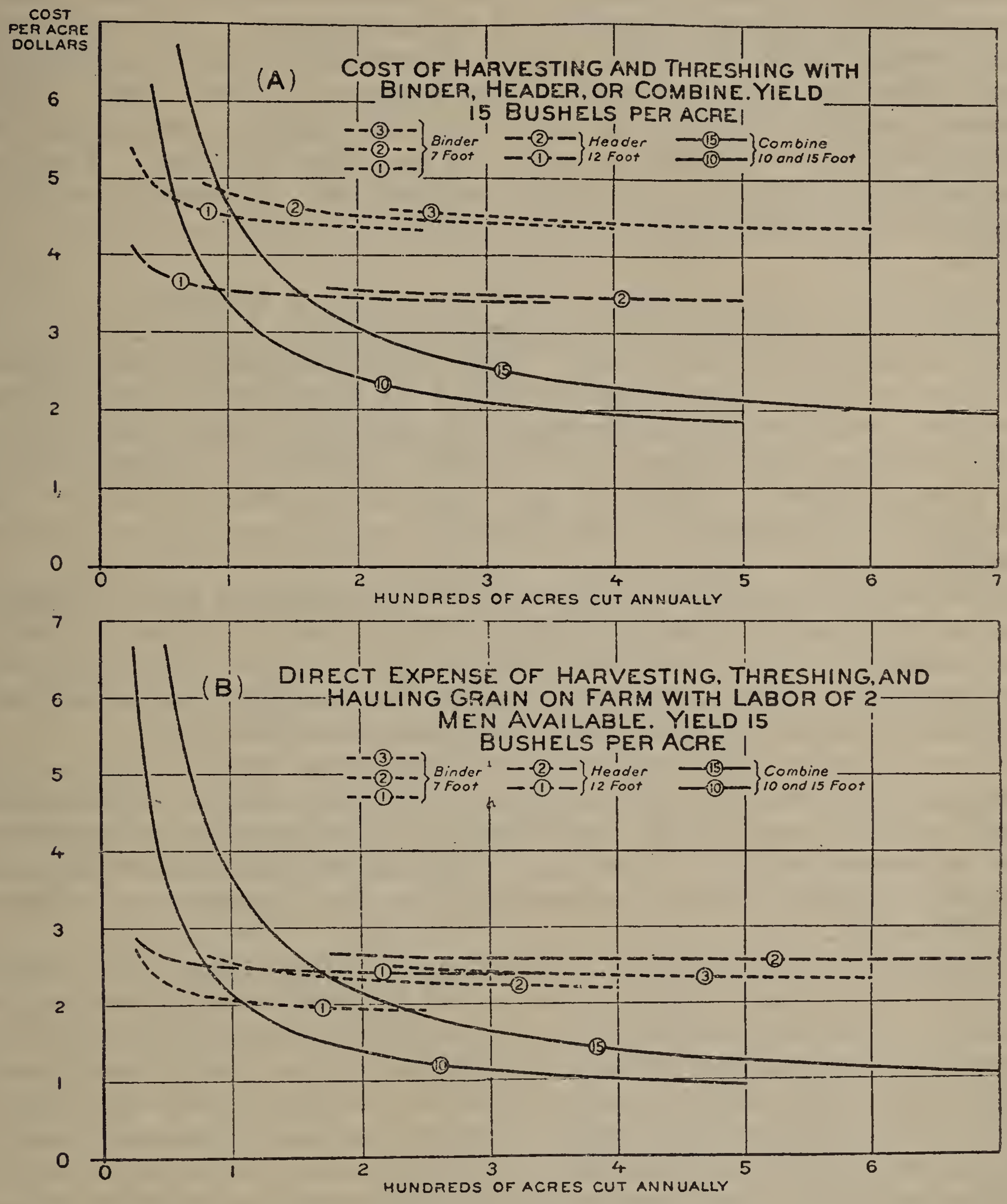

FIG. 1.—Comparison of harvesting costs of different specified acreages for binders, headers, and combines and comparison of expenses usually met for specified acreages by each method of harvesting

general comparison of harvesting costs for different acreages of grain cut by binders, headers, or combines.

The costs of harvesting with a combine, used for this figure, are computed by applying prices to the average quantities of labor and material used as shown by the previous tables on combine operation.

Rates of payment for labor and material used for binding and heading are comparable to the rates applied to the elements of cost for combining.[4]

With interest and depreciation included in costs, the large investment in machinery causes a high harvesting charge per acre when a small acreage is cut. Depreciation charges are based in all cases on an estimate of 8 years as the life of the combine, and the same yearly depreciation is charged regardless of the acreage cut. In actual service it seems likely that the yearly depreciation would be less for small than for large acreages. The amount of work done would probably affect the length of service of the machine particularly in instances where very high or very low acreages were cut. The depreciation charged to the binders is based on 10[5] years of service, whereas that charged against the headers is based on 15 years of service.

The cost curve for combines shows the effect of acreage cut on cost per acre and emphasizes the necessity of having a large acreage in order to decrease the acre cost. Since the investment in the 10-foot machine is smaller than that in the 15-foot machine and other costs per acre are approximately the same, the total acre cost of harvesting is less for the 10-foot than for the larger machine. As operated in the Great Plains in 1926 the unit cost was generally lower for the smaller combines up to the acreage usually cut by a 10-foot machine.

The cost curves of the combine and binder indicate that if harvest and threshing cost alone are considered, the small combine is a more economical machine than the binder where 60 or more acres of grain are to be cut. With a 15-foot combine, harvesting costs would not be reduced unless approximately 100 acres were to be cut.

When a header is used, the cost is somewhat lower than is the acre cost for harvesting with a binder. Compared with a header the small combine would probably be the more economical machine where 100 or more acres were to be cut. The 15-foot combine would not be more economical than the header unless the acreage was as large as 150 acres.

For larger acreages the cost of cutting and threshing with a combine was much lower than is the cost when either a binder or header is used. The small combine is apparently more economical than the large size up to the limit of its capacity, but the cost per acre decreases rather slowly after the acreage cut is greater than 300 or 400 acres, and the advantage of getting the grain cut and threshed quickly would probably more than offset the small reduction in costs shown. Where more than 300 acres are cut the difference between acre costs of 10-foot or 15-foot machines is small and the variation between costs of separate machines is such that in many instances the larger machine would probably be as economical as, or more economical than, the smaller one. Table 12 shows the factors considered in computing the costs used in Figure 1–A.

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[4] Labor and materials used for binding and heading are taken from values given in U. S. Department of Agriculture Bulletin No. 1198.

[5] U. S. Department of Agriculture Bulletin No. 338.

TABLE 12.—*Charges made for different harvesting methods, per acre*

Item of cost	Combine, 10-foot		Combine, 15-foot		Binder, 7-foot		Header, 12-foot	
	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
Man labor [1] ....man-hours..	0.69	$0.41	0.65	$0.39	3.6	$1.80	2.8	$1.40
Horse labor [2] ....horse-hours..					5.9	.59	4.1	.41
Tractor		.60		.60				
Fuel [3] ....gallons..	1.3	.32	1.4	.46				
Oil [3] ....do....	.04	.03	.05	.04				
Grease ....pounds..	.06	.01	.05	.01				
Twine [4] ....do....					2	.28		
Repairs		.10		.10		.05		.05
Threshing 15 bushels [5]						1.50		1.50
Variable costs		1.47		1.50		4.22		3.36
Depreciation [6]		152.00		201.00		22.50		13.33
Interest [7]		37.80		62.52		6.75		6.00

[1] Labor on combines charged at 60 cents per hour; labor on binder and headers at 50 cents per hour.
[2] Horse labor charged at 10 cents per hour.
[3] Fuel charged at 25 cents per gallon, oil at 75 cents per gallon.
[4] Twine charged at 14 cents per pound.
[5] Threshing at 10 cents per bushel for a 15-bushel yield.
[6] Based on 8 years life for combine, 10 years for binder, 15 years for header.
[7] Annual charge per machine at 6 per cent.

The farmer on his own farm with a certain supply of labor and power available may be more interested in actual payments than in total charges as shown in Figure 1–A. The costs which he must meet in cash are of first importance. Figure 1–B shows the estimate of immediate costs for different machines with no allowance made for unpaid labor, power, or interest on the investment. To harvest with a combine the grain crop on a farm having available the equivalent of the labor of two men would require the hired service of one man for hauling, the running expenses for operating the combine, and a charge for replacement of the machine. With one binder no additional labor would be needed for cutting, the extra threshing labor might be exchanged, and the only immediate costs would be for twine, operating expenses of the binder, and cost of threshing. If more than one binder, or if a header were used, more labor necessarily would be hired for harvest.

Table 13 shows the cash-cost factors considered in the comparison shown in Figure 1–A. On this basis the harvesting costs for a binder would be less than for a small combine unless 110 or more acres were to be cut. For acreages less than the approximate maximum to be cut with a binder the cost is less than that for a large combine. With a header the immediate costs are somewhat higher and the small combine might be the cheaper with 80 or more acres to be cut. A large combine would be cheaper for cutting more than 175 acres. For larger acreages than those shown the harvesting costs would be lower if a combine were used.

If extra labor or additional charges are needed on a given farm the cash costs would be somewhat higher and the point where a combine would prove profitable would lie somewhere between the acreages indicated in Figures 1–A and 1–B.

The harvesting and threshing costs for binders and headers are based on yields of approximately 15 bushels per acre. With higher

yields the threshing costs would increase proportionally to the increase in yield and a comparison of harvesting costs would show a still greater advantage for the combine. The costs of combining as computed from the available data are for yields averaging 20 bushels per acre. Costs per acre for the combine are so little affected by differences in yield that the cost for combining a yield of 15 bushels would be practically the same as for a yield of 20 bushels per acre. It is only where the grain is very heavy and the rate of travel, or width of swath taken, must be reduced that yield has an appreciable effect on acre cost of cutting with a combine.

TABLE 13.—*Cash costs per acre incident to harvesting with different methods where the labor of two men is available and threshing labor is exchanged*

Item of cost	Combine, 10-foot		Combine, 15-foot		Binder, 7-foot, cost			Header cost	
	Quantity	Cost	Quantity	Cost	1 machine	2 machines	3 machines	1 machine	2 machines
Extra labor[1] ... hours	0.4	$0.16	0.3	$0.12		$0.27	$0.36	$0.80	$0.96
Fuel[2] ... gallons	1.3	.32	1.4	.36					
Oil[2] ... do	.04	.03	.05	.04					
Grease ... pounds	.06	.01	.05	.01					
Repairs		.10		.10	$0.05	.05	.05	.05	.05
Twine[3] ... pounds					.28	.28	.28		
Threshing[4]					1.50	1.50	1.50	1.50	1.50
Variable costs		.62		.63	1.83	2.10	2.19	2.35	2.51
Depreciation[5]		152.00		303.00	22.50	45.00	67.50	13.33	26.67

[1] Charged at 40 cents per hour.
[2] Fuel charged at 25 cents, oil at 75 cents per gallon.
[3] Charged at 14 cents per pound.
[4] Charged at 10 cents per bushel for a 15-bushel yield.
[5] Per machine average depreciation based on 8 years life for a combine, 10 years for a binder, and 15 years for header equipment.

HARVESTING LOSSES

Losses of grain resulting from the different methods of harvesting were determined in Oklahoma, Kansas, Nebraska, and Montana by actual counts of the number of heads left on the ground in 259 fields cut by combines, 59 fields cut with headers, and 34 fields cut with binders. The per acre yield in fields cut with combines was determined from samples taken previous to harvesting. The losses on headed and bound fields were calculated on the basis of yields obtained from the combined fields.

Forty-one of the 190 fields of winter wheat cut with the combine had losses of less than 1 per cent, 106 less than 2 per cent, and 137 less than 3 per cent. Losses greater than 3 per cent occurred with an uneven or partly lodged crop, on rough land, with poor machines, through careless operation, or in very windy weather. The average loss from harvesting winter wheat with combines was 2.6 per cent. Fields cut with headers showed an average loss of 3.3 per cent and fields cut with binders showed an average loss of 6.1 per cent. These percentage losses are based on a yield of 20.4 bushels per acre. The loss per acre was 32 pounds after the combine, 40 pounds after the header, and 74 pounds after the binder. Heads cut off and dropped on the ground were the greatest source of loss in combining and heading. Additional losses in heading occurred in loading the header

barge and hauling to the stack. The losses in binding include the cutting loss, the loss between the canvasses, loss from the binding platform and bundle carrier, heads dropped in shocking and hauling, and heads left in shock bottoms. Losses around the stacks and incident to threshing are not included.

THRESHING LOSSES

The losses in threshing were measured by catching the straw on a large canvas while a known quantity of wheat was being threshed and measuring the wheat blown out with the straw. Blanket tests of 33 combines and nine separators were made to determine which type of machine was the most efficient. The loss measured included only the threshed grain which was blown or carried through with the straw. Thirteen of the 33 combines were carrying over less than 1 per cent of the grain threshed and 21 were carrying over less than 2 per cent. All losses of over 2 per cent probably were due to poor adjustment and operation or to overloading of the thresher. Eight of the nine separators tested were losing less than 2 per cent. The average loss from the combines was 1.9 per cent and from the separators 1.1 per cent.

Although on the average the combines were wasting more grain than the separators, these results show that many of the combines were operated with no greater waste. The uniform feeding of the combine thresher probably partly offset differences due to the more skillful operation of the separators.

OTHER FACTORS TO BE CONSIDERED IN CHOOSING BETWEEN HARVESTING WITH A COMBINE AND OTHER METHODS

Considerations other than the direct cost of harvesting must not be omitted in determining the advisability of using a combine.

To a farmer with a small acreage the yearly saving in harvest costs may not be great and, although the investment in a combine might be profitable for the entire life of the machine, if a short grain crop occurred the first season, the necessity of making payments on the machine might lead to temporary financial difficulties.

The extent of losses to standing grain has not been fully determined. As the grain must stand in the field until it is dead ripe before cutting can begin, there frequently is some loss from shattering and in some seasons there is the possibility of loss from lodging. A crop of approximately 60 acres could be cut with a 7-foot binder and shocked after ripening before that grain would have been ready for combining. Losses which can definitely be attributed to the machine are lower for the combine than for the binder, and there is the possibility of losses from grain spoiling in the shock and even in the stack. But it seems probable that during a period of years such losses would be less than the losses from grain standing in the field. This loss from allowing grain to stand is not generally considered to be a serious one by farmers in the Great Plains, but greater loss may be expected under more humid conditions, where lodging is more frequent, and where the varieties grown shatter more easily than do the hard winter wheat grown in the Great Plains.

Grain which is allowed to stand in the field for a considerable period after ripening may deteriorate in quality. Few of the farmers interviewed considered this deterioration, due to loss of color or test weight, serious enough to affect materially the price received for the grain. Some deterioration was reported in some localities after a series of showers, and in more humid regions a more serious loss could be expected.

In more humid regions much of the grain cut with a combine would have a high moisture content and might present some difficulties in storing and marketing. Without some economical means of drying grain that has a high moisture content, the use of the combine in humid regions may be limited.

The average length of day for combining in the Great Plains was 10 hours. In certain localities the humidity and the condition of the grain were such that the machine could have been operated almost continually. A few operators did use their machines at night and many worked 15 or 16 hours on some days. Even when showers had fallen the humidity was generally low and the grain dried quickly, so that little time was lost in the field. In localities of greater rainfall and higher humidity many operators delay starting in the morning until the grain has had time to dry. When the humidity is still higher it may be necessary for the operator to lose more time each day and the number of working hours may be reduced, so that the acreage cut per day and during the season may be less than reported in the Great Plains. Moreover, the grain could hardly be left in the field so long in the more humid regions as in these districts, and the season for the operation and total acres cut by a given machine would be less than for the drier region.

WHAT ACREAGE SHOULD BE HANDLED BY A SINGLE COMBINE?

The 10-foot combines cut, on the average, 25 acres per day and the 15-foot combines averaged 35 acres per day. At this rate, with a harvest season lasting 15 days, the 10-foot machine would harvest 375 acres and the 15-foot machine would harvest 525 acres. For all 10-foot machines the average cut during the season was 457 acres, and the 15-foot machines averaged 574 acres and the 16-foot machines averaged 682 acres. The acres cut per day by machines of a given size were practically the same in all localities. The differences in total acres cut were due principally to variations in the length of the harvest season. Most of the machines in all localities were cutting sufficient acreage to reduce the cost per acre to a comparatively low figure. Many of the operators considered that the investment would be warranted with even a smaller acreage than they were cutting. A great many considered that their combines were able to handle a larger acreage than they were cutting.

Table 14 shows the average of estimates made by farmers as to the minimum acreage for which they would own a combine and their estimate of the acreage which a combine would cut satisfactorily. The average minimum acres, as estimated, ranged from 127 acres for the 8-foot combine to 400 acres for the 20-foot machine. The minimum for 10-foot combines was estimated at 196 acres and the minimum for 15-foot machines averaged 276 acres.

TABLE 14.—*Owners' estimates of minimum and maximum acreages cut with combine*

Type of combine	Width of cut	Farms reporting	Farms reporting minimum acreage		Maximum acreage			
					Farms reporting one kind [1]		Farms reporting two kinds [2]	
	Feet	*Number*	*Number*	*Acres*	*Number*	*Acres*	*Number*	*Acres*
Tractor-drawn with power take-off	8	25	24	127	24	258	1	350
	10	10	10	196	10	427	3	450
Horse drawn	12	3	3	158	3	450		
	15	3	3	250	3	533		
	16	2	2	400	2	675		
Tractor-drawn with auxiliary engine	12	56	47	209	43	400	9	800
	15	51	46	276	44	646	3	1,100
	16	103	82	290	81	708	9	1,078
	20	3	3	400	3	850	2	1,125
All farms		256	220	248	213	565	27	894

[1] Spring or winter wheat.

[2] Both.

The maximum acreage estimated by farmers was nearly the same as the average acres cut in 1926 by the same size of machine. The combines generally were being used almost to their full capacity. For each size of machine the number of acres cut in 1926 was very nearly the same as the estimated maximum number of acres. Where both spring and winter wheat were harvested, the acres cut by each machine were increased, and for some groups the average acres cut exceeded the acres which the operators considered the maximum capacity of the machine.

The minimum acreage which a given machine will cut profitably is determined by the cost of alternate methods of harvesting. With a combine the acre cost will be less for a large than a small acreage, and the profitable minimum acres will be set at a point below which some other method will prove cheaper. The actual cost of the harvesting and threshing operations should be supplemented by a consideration of the probable effect of each method on the labor program of the farm, the effect on following crops, and the effect on the condition and value of the grain threshed.

In a locality where binders are used in preference to headers an operator may find his harvest costs decreased by a small combine if he has 60 acres or more of grain to cut. Based on the cost figures used in constructing Figure 1, his per acre harvesting cost would be approximately $4.60. In the Great Plains region custom work was being done for $3 per acre, and, based on present costs, an operator could hire his cutting more profitably at that rate than purchase his own combine unless he has at least 125 acres. With a 15-foot machine his own acreage would have to be at least 100 acres before the costs would be less than harvesting with a binder, and he would have to have 200 acres to cut before his cost would be less than the cost of hiring the grain cut with a combine. The profitable minimum acreage, where heading is the alternative, would be somewhat greater than where a binder is used.

The maximum acreage which a combine will handle is dependent upon the size of the machine and the length of the harvest season. In the Great Plains, where the hard winter wheat will stand for a considerable time without deteriorating in quality, the maximum

acreage which a combine can cut becomes very high and many 16-foot machines cut more than 1,000 acres. A 15-foot machine cutting an average of 35 acres per day would cut 525 acres in 15 cutting days, or 700 acres in 20 days. The largest acreage reported cut by a 15-foot machine was 1,100 acres. A 10-foot machine cutting an average of 25 acres per day would harvest 375 acres in 15 days or 500 acres in 20 days of cutting. The largest acreage reported cut by a 10-foot machine was 640 acres.

SPECIAL EQUIPMENT USED ON COMBINES

On many models of combines the purchase and use of at least a part of the equipment is optional with the farmer. Some accessories will be desired under particular conditions that would not always be used. The more important items of extra equipment are: The extension to the cutter bar and platform, the straw spreader, and the grain tank. Straw bunchers, sacking attachments, self feeders, and straw carriers are not often used on combines in the Great Plains.

The addition of the extension cut increases the length of the cutter bar and platform and increases the cutting capacity of the machine. One-half of the machines equipped with an auxiliary engine made use of the extension cut. Of the 56 machines with a 12-foot cut, 23 were regular 9-foot machines with a 3-foot extension. None of the 9-foot combines were used without an extension. Of the 51 machines with a 15-foot cut, 31 were regular 12-foot machines with 3-foot extension, and of the 104 combines with a 16-foot width of cut, 51 were 12-foot machines with a 4-foot extension. For a given make of machine the threshing and separating capacity may be the same for a 12-foot or for the 12 and 16-foot cut. The separating capacity of the machines differs somewhat between machines of the same cutting width but of different model. For most of the machines, the thresher could handle ordinary yields of grain without difficulty even with the extension. A few farmers with very heavy wheat did not use the extension in 1926 although one had been used in previous years. Where the yield is very heavy or the grain is lodged the extension may be removed in preference to reducing the rate of travel.

The recent models of combines used in the Great Plains usually are equipped with a straw spreader to distribute the straw behind the machine rather than leave it concentrated in a narrow strip behind the straw rack. Straw spreaders were more generally used on the 15-foot and 16-foot machines than on those with a 12-foot cut. The 12-foot machines were earlier models, and on many the straw spreader was not included as a part of the regular equipment. Only a few farmers who had spreaders were not using them. In some cases where the straw was heavy the spreader was removed either because the spreader was giving trouble or in order to drop the straw so that it could be burned in the windrow.

A few machines were equipped with straw bunchers which caught the straw and dropped it in piles on the field. Few bunchers are used in the Great Plains region, where the straw is not saved for feed and often is not heavy enough on the field to interfere with later cultivation of the soil.

The common practice in the Great Plains is to handle the threshed grain in bulk. A few machines were equipped with sacking attachments but all except one of the combines on which records were obtained used either grain tanks or wagons to handle the grain. Where the grain is hauled by truck there is a distinct advantage in using the tank as the grain can be run directly from the tank to the truck, and the labor of shoveling is eliminated. Where grain is stored on the farm or hauled to market in wagons, there may be no advantage in using a grain tank. The grain tank is generally used on new machines, and it has been added to many of the older ones. When motive power is insufficient as on hilly land, in light soil, or when a light tractor is used, the tank may be removed and a wagon drawn by horses substituted in order to relieve the tractor of some of the load. Some farmers report considerable side draft on the combine without a grain wagon or tank attached.

Other attachments such as self-feeders and straw carriers may be used to facilitate stationary work to be done with the separator. Some stationary threshing is done without these attachments but additional labor then is required for feeding the machines and disposing of the straw.

CUSTOM WORK WITH A COMBINE

A farmer with a small grain acreage may find it advisable to obtain a combine for his own grain and to depend on doing custom cutting for his neighbors. More than half of the combine owners did some custom work with their machines.

The profit in custom cutting depends largely on the rate received per acre. In those areas where the combine has been used for only a short time the rate per acre is higher than in other areas where the machines are in more general use. The acre rates varied from $4 per acre in Texas to $2.50 per acre in Montana. The general rates were about $3 per acre in most of the localities. The charge for cutting is usually higher during the first part of the harvest season than later. Those who expect to hire their grain combined are willing to pay a higher rate in order to have the work done early and so reduce the risk of loss from shattering, lodging or bleaching of the grain. Later in the season, as more operators finish their own acreage, competition for cutting may reduce the rate. An operator who wishes to contract a large acreage for his machine may charge less than the customary rate if the cutting may be postponed until the latter part of the season.

Table 15 shows the owned acreage and custom acreage cut by machines of different sizes. For most of the groups the amount of custom work is almost as great as the cutting on home farms. Except for differences due to rates of cutting, the returns per acre for custom work are very nearly the same for all groups of machines. The returns, exclusive of fixed charges, depreciation and interest, and repairs, for cutting at $3 per acre would be approximately $2 per acre. This would represent the expected return to the combine after deducting costs of labor, fuel, and lubricants. Many farmers do much of the work themselves, and are interested primarily in the return to themselves for the use of the combine and tractor. With no charge for labor the returns would be approximately $2.50 per acre.

TABLE 15.—*Custom work done by combine owners in addition to cutting their own crops*

Type of combine	Size of machine	Total combines	Doing custom work	Owners' crop	Custom cutting	Rate per acre for cutting	Total receipts	Total expenses [1]	Return to— Combine [2] Total	Return to— Combine [2] Per acre	Return to— Combine and labor [3] Total	Return to— Combine and labor [3] Per acre
	Feet	*Number*	*Number*	*Acres*	*Acres*							
Tractor drawn with auxiliary engine	12	56	23	223	201	$3.00	$558	$129	$429	$2.13	$500	$2.48
	15	51	36	294	289	3.10	855	208	647	2.24	744	2.57
	16	104	79	366	324	3.18	978	195	783	2.42	880	2.72
	20	3	3	637	363	2.70	1,052	254	798	2.20	941	2.59
Tractor drawn with power take off	8	25	12	209	128	2.90	317	93	224	1.75	285	2.23
	10	10	10	292	164	3.75	546	117	429	2.61	501	3.04

[1] "Expenses" include charges for labor, fuel, oil, and grease for the season. No other charges are included.
[2] Total return to combine is the profit for use of combine and tractor with cost of labor, fuel, and lubricants deducted, but with no charge made for depreciation and repairs.
[3] Return to combine and labor is the profit for operating a combine and tractor with charges made for fuel and lubricants, but with no deduction made for labor, depreciation or repairs.

Whether this return would increase the net earnings of the farmer would depend upon the value of his labor in doing other work on the farm, or on the cost of hiring labor to perform the needed work. It might be more profitable for the farmer to allow the machine to be idle and use his time to prepare land for the succeeding crops.

The possibility of doing cutting for others will enable a farmer to own and operate profitably a combine for his own grain where the saving in his own harvest bill is supplemented by profit from outside work.

With an increase in the number of combines in an area and resulting competition among combine owners, the rates for cutting may be reduced until the profit in custom cutting is decreased. Those who are considering the purchase of a combine with the expectation of doing custom work should consider a possible lowering in the pay for cutting and a smaller acreage to cut each year.

SUMMARY

The combined harvester-thresher has given general satisfaction in harvesting wheat in the Great Plains region. Advantages of the combine are that it lowers the cost of harvesting and threshing, reduces the amount of labor required, and shortens the harvest and threshing period.

Combines most generally used in the region have a 12, 15, or 16 foot cut and are equipped with an auxiliary engine and drawn by a tractor. Power-drive machines with an 8 or 10 foot cutter bar are also used.

Grain cut annually by combines of all types and sizes averaged 553 acres per machine. The capacity of the machine is primarily dependent on the width of cut and the length of the harvest season. The average for different types of machines ranged from 275 acres for the 8-foot machines, to 1,077 acres for the 20-foot machines. The average cut by 16-foot machines is 682 acres.

In general, wheat was the only crop harvested. The acreage of other crops was small, and the time of ripening so nearly the same as that for wheat, that the use of the combine on other crops did not materially increase the capacity of the machines. The average rate of travel is 2.75 miles per hour, and for most machines varies between 2.5 and 3 miles per hour. The size of machine has no apparent effect on the rate of travel.

The average length of the working day was 10.4 hours.

Acres cut per hour ranged from 1.6 for the 8-foot to 4.5 for the 20-foot machines. The 16-foot combines averaged 3.8 acres per hour. The cut per hour for each foot of width is approximately 0.22 acres for most machines. The rate of cutting depends on the rate of travel and on the size of the machine. For yields ordinarily reported in the Great Plains region, the rate of cutting is only slightly affected by the yield per acre.

The more important elements of cost for harvesting with a combine are: Charges for labor, fuel, repairs, depreciation on the machine, and interest on the investment.

On the average, 0.6 of a gallon of gasoline per acre was used in the auxiliary engine. Fuel consumption per acre in the auxiliary engine is affected somewhat by the size of machine, rate of travel, and the yield of grain.

A tractor with a drawbar rating of 15-horsepower was used on most of the combines, although one-third of the 12-foot machines were drawn by smaller tractors. Fuel used in the tractors on combines equipped with auxiliary engines averaged 0.8 gallons per acre. The larger combines were slightly more economical than the small machines in the use of fuel per acre.

Fuel used in both auxiliary engine and tractor averaged 1.4 gallons per acre. The total fuel used per acre in machines with power-drive was only slightly less.

Less than one-half of the labor used on combines was hired labor. The average amount of man labor furnished by the farmer for harvesting with a combine is 0.75 man-hours per acre, as compared with 3.6 man-hours usually furnished by the farmer for harvest and threshing where grain is cut with a binder and 2.8 man-hours where the cutting is done with a header. The crew required to operate the combine is smaller than the crew used for heading or for binding if more than one binder is used.

Repairs are estimated from available data at 10 cents per acre.

For all combines, depreciation averaged 44 cents per acre. There is no apparent relation between the acres cut annually and the estimated life of the machine. The per-acre depreciation charge is less for large than for small acreages cut by the same size of machine.

Interest charges are fixed, and the per-acre charge is less for large than for small acreages.

Under similar conditions, harvesting costs per acre show some variation between farms in the same area.

For small acreages the expense of harvesting with a combine is greater than for either a binder or header. Where 75 or more acres are to be harvested the small combine may prove more economical than other machines. The large combine may be more economical than a binder or header if more than 100 acres are to be cut. The

choice between a large or small combine should be made on the basis of the capacity of the machine and the acreage to be cut. Where 300 or more acres are to be cut, the fixed charges of the combine are reduced to a low figure and the combine reaches its highest efficiency.

Where only the usual direct costs are considered, 100 acres could be harvested as cheaply with a binder or header as with a small combine.

The average harvesting loss with combines is 2.6 per cent of the total yield as compared with 3.3 per cent for a header and 6.1 per cent for a binder. The actual loss for grain cut with the combine averaged 32 pounds per acre as compared to 40 pounds for the header and 74 pounds for the binder.

The average threshing loss with combines was 1.9 per cent of the grain threshed as compared to 1.1 per cent for the stationary tractor.

Factors other than harvest costs which should be included in a consideration of the use of the combine are: Possibility of loss of grain from weather or from shattering, disposal of straw, quality of grain, and moisture content of the grain as it is threshed.

A 10-foot combine should harvest 375 acres in a 15-day harvest season. The minimum profitable acreage in the Great Plains where combines for custom cutting are available would be about 150 acres, while the maximum would be about 640 acres. A 15-foot combine should harvest about 500 acres in 15 days, with a minimum of 200 and a maximum of 800 acres.

Most machines were cutting as much as the operators considered the maximum capacity of the machine.

More than one-half of the combine owners were doing some custom cutting with their machines. The returns from custom cutting may enable an owner with a small acreage to obtain a profit on the investment in a combine although his own acreage would not warrant his purchasing a machine.

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